E07-002: Wide-Angle Compton Scattering

David Hamilton
on behalf of the E07-002 Collaboration

Hall C Users Meeting
18th January 2008

Presentation Outline:

- Overview of the physics of Wide-Angle Compton Scattering
- Jefferson Lab WACS programme
- Experimental and analysis techniques
- Installation and run plan
- Summary

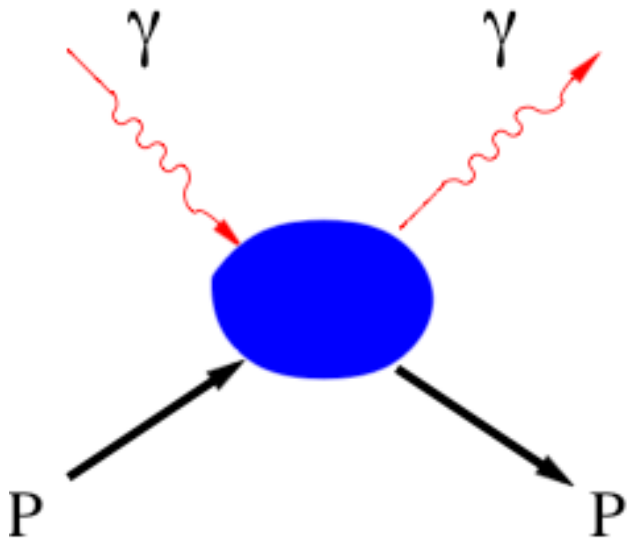
Why WACS?

Proton Compton scattering in the wide-angle regime (s, -t, -u >> $m^2_{nucleon}$) is a powerful and under-utilised probe of nucleon structure.

Similar physics in play as in elastic ep or DVCS: characterise electromagnetic response of the nucleon without complications from additional hadrons.

Main issues:

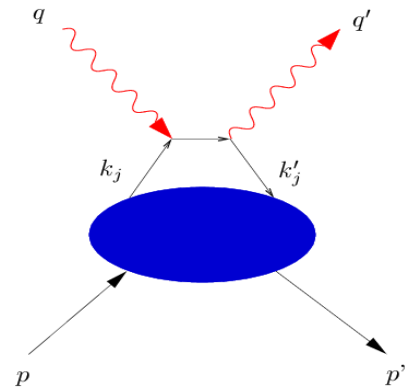
- Competing reaction mechanisms
- Interplay between hard and soft processes
- Threshold for onset of asymptotic regime
- Role of hadron helicity flip

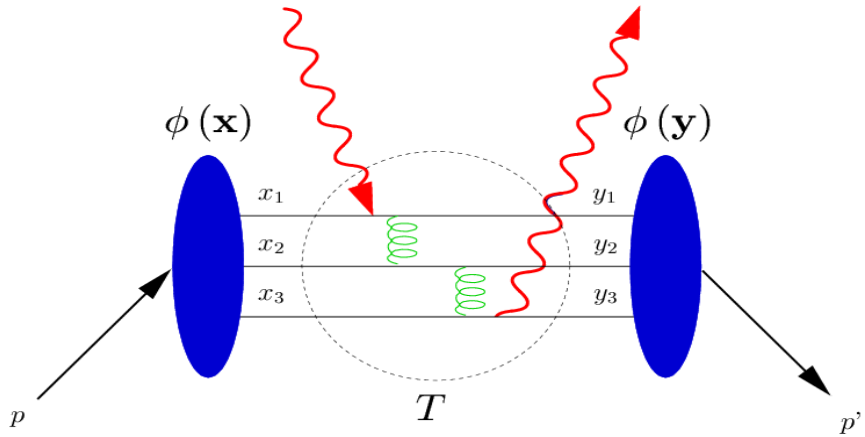


Test of Reaction Mechanism

A number of reaction mechanisms proposed over the years:

- Regge poles - VMD - since 1960's …, Laget
- pQCD - two-gluon - Brodsky, …, Guichon&Vanderhaeghen, Brooks&Dixon, Thomson et al.
- Diquark model - Guichon&Kroll, 1996
- Leading quark - Brodsky et al., 1972
- GPDs (handbag) - Radyushkin, Kroll et al.
- CQM - G.Miller





GPDs in the Handbag Approach

$$\gamma p \to \gamma p \qquad\qquad ep \to ep$$

$$R_V(t) = \sum_a e_a^2 \int_{-1}^{1} \frac{dx}{x} H^a(x,0,t), \qquad F_1(t) = \sum_a e_a \int_{-1}^{1} dx\, H^a(x,0,t),$$

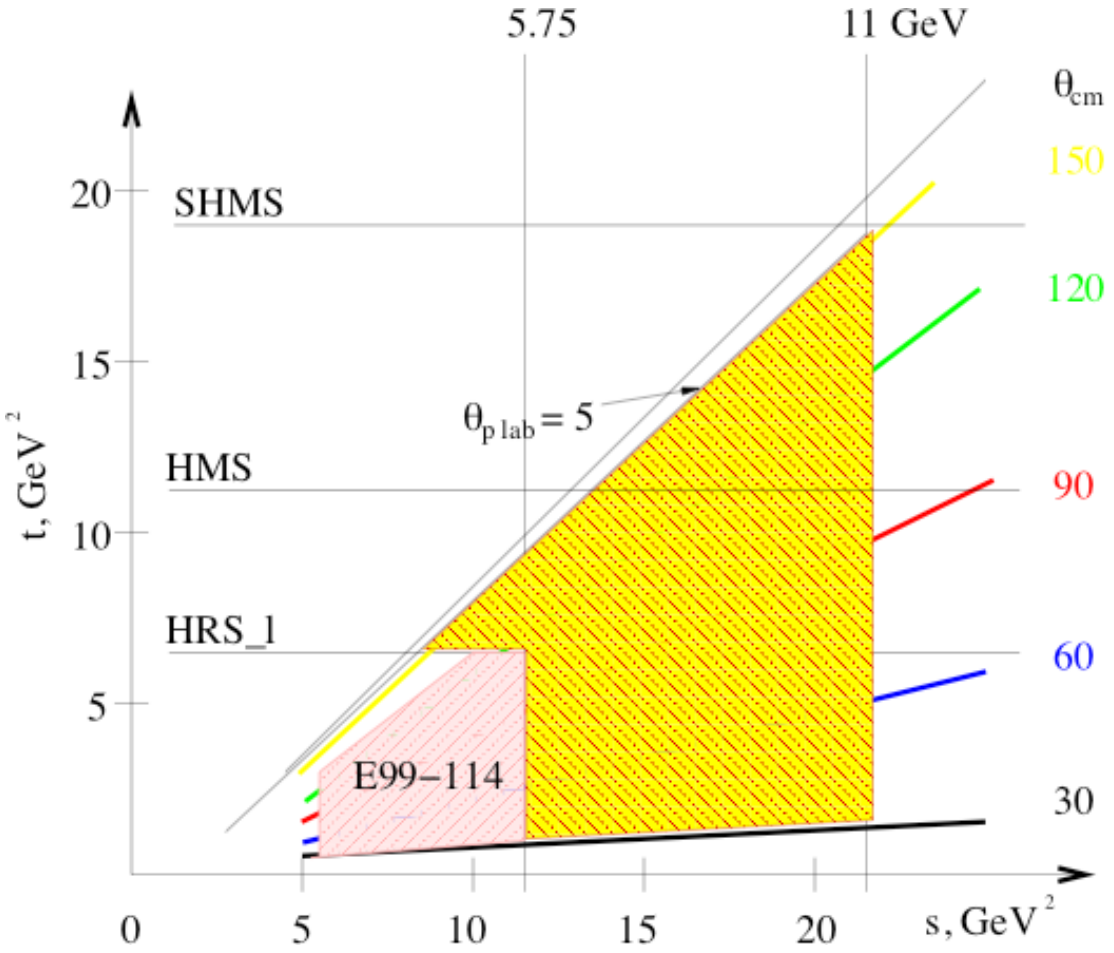
$$R_A(t) = \sum_a e_a^2 \int_{-1}^{1} \frac{dx}{x} \,\mathrm{sign(x)}\, \hat{\mathrm{H}}^{\mathrm{a}}(\mathrm{x},0,\mathrm{t}), \qquad G_A(t) = \sum_a \int_{-1}^{1} dx\, \mathrm{sign(x)}\, \hat{\mathrm{H}}^{\mathrm{a}}(\mathrm{x},0,\mathrm{t}),$$

$$R_T(t) = \sum_a e_a^2 \int_{-1}^{1} \frac{dx}{x} E^a(x,0,t), \qquad F_2(t) = \sum_a e_a \int_{-1}^{1} dx\, E^a(x,0,t),$$

GPD	x^{-1} moment	x^0 moment	$t=0$ limit
$H^a(x,0,t)$	$R_V(t)$	$F_1(t)$	$q(x)$
$\hat{H}^a(x,0,t)$	$R_A(t)$	$G_A(t)$	$\Delta q(x)$
$E^a(x,0,t)$	$R_T(t)$	$F_2(t)$	$2J(x)/x - q(x)$

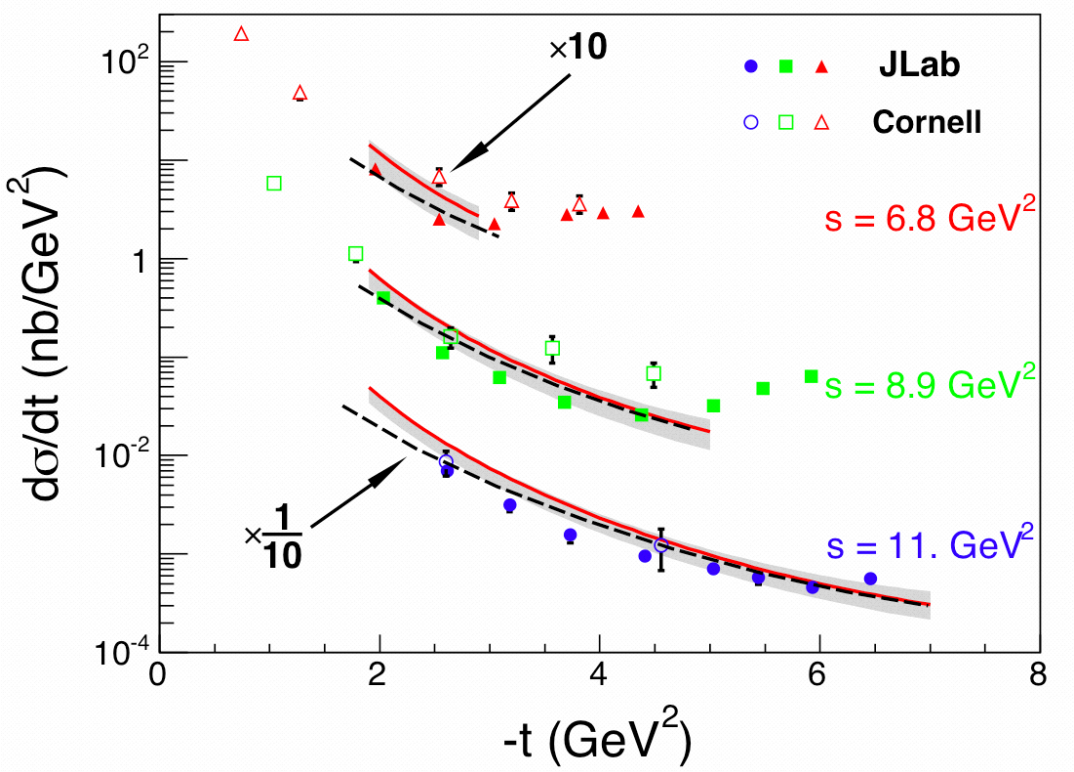
The Jlab WACS Programme

- E07-002 is part of an ongoing WACS programme at Jlab.
- E99-114 measured cross sections over a broad kinematic range and polarisation observables at a single kinematic point.
- Polarisation result was strong but needs further confirmation at higher s, -t and -u.

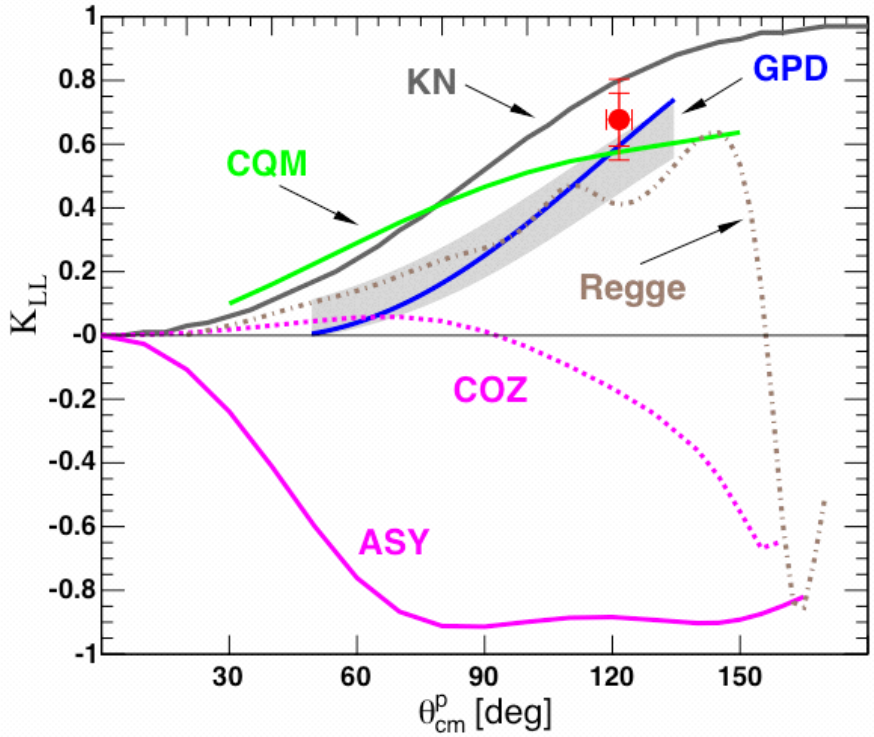


E99-114 Results

Danagoulian et al, PRL 98, 152001



Hamilton et al, PRL 94, 242001



- Disagreement with pQCD predictions **but K_{LL} at low -u.**
- Handbag predictions show good agreement.

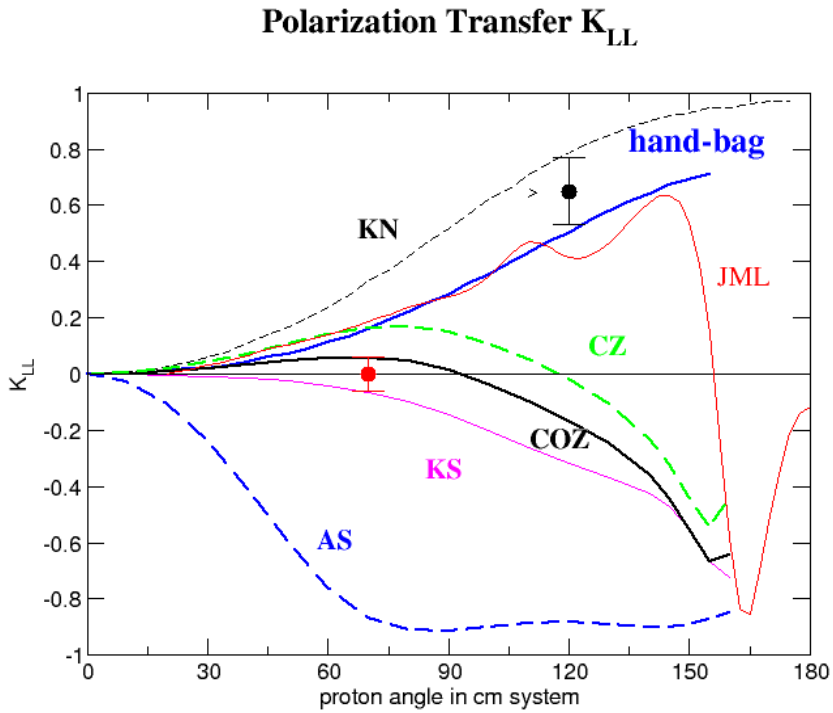
$s = 6.9\ GeV^2$
$-t = 4.0$
$\mathbf{-u = 1.13}$

Experimental Goals

$$K_{LL}\frac{d\sigma}{dt} \equiv \frac{1}{2}\left[\frac{d\sigma(\uparrow\downarrow)}{dt} - \frac{d\sigma(\uparrow\downarrow)}{dt}\right]$$

$$K_{LT}\frac{d\sigma}{dt} \equiv \frac{1}{2}\left[\frac{d\sigma(\uparrow\rightarrow)}{dt} - \frac{d\sigma(\downarrow\rightarrow)}{dt}\right]$$

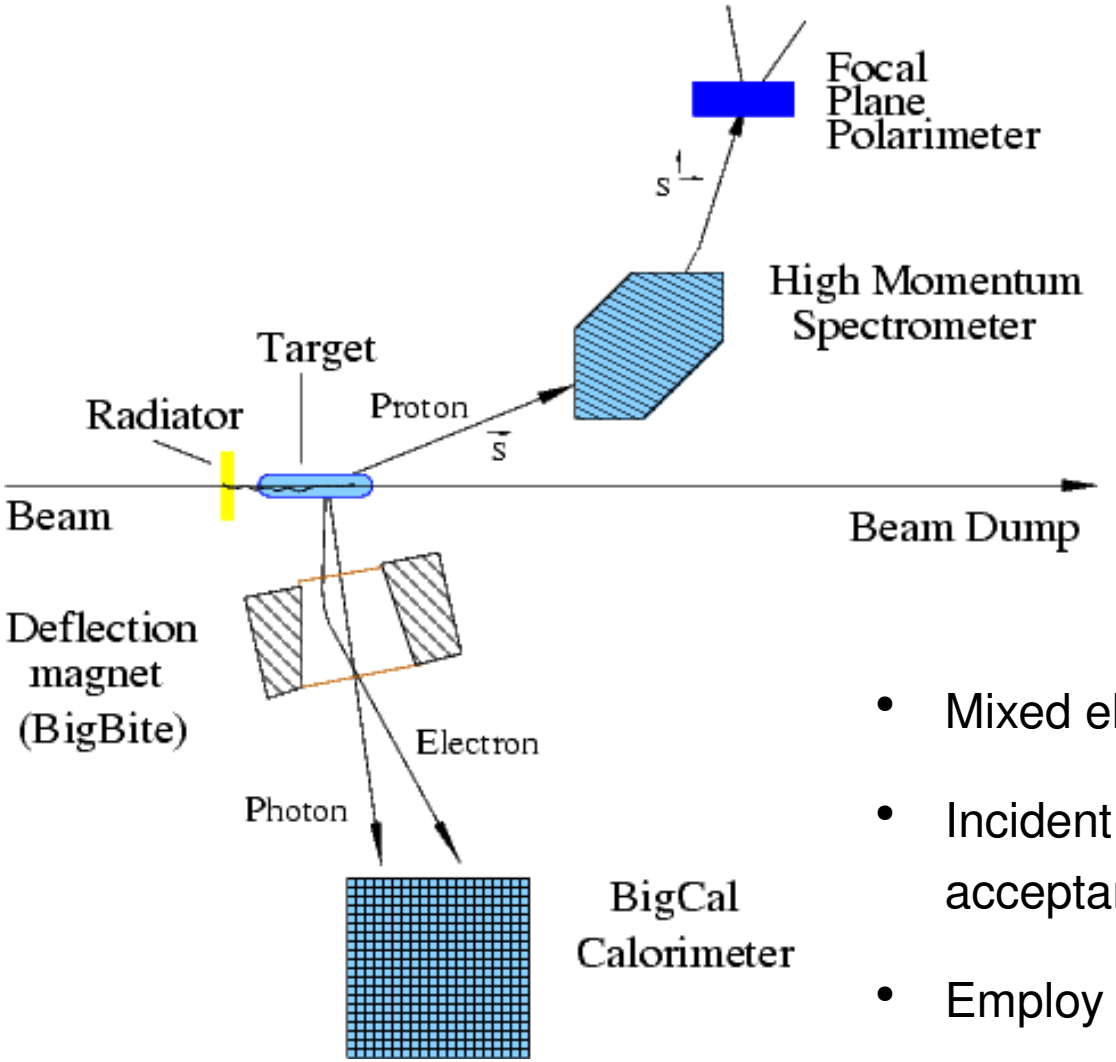
$$P_N\frac{d\sigma}{dt} \equiv \frac{1}{2}\left[\frac{d\sigma(\uparrow)}{dt} - \frac{d\sigma(\downarrow)}{dt}\right]$$

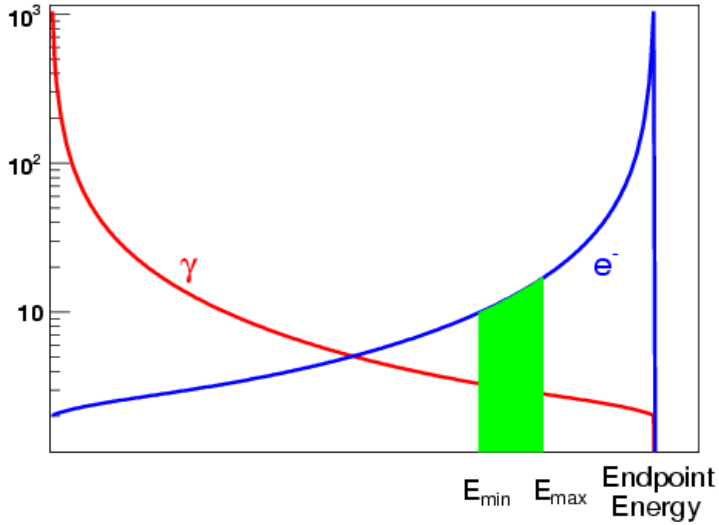


1. Provide a stringent test of the notion that the WACS proceeds via photon interaction with a single quark - K_{LL}.

2. Measure K_{LS} and P_N in order to stimulate in further development of the theoretical framework.

Experimental Technique

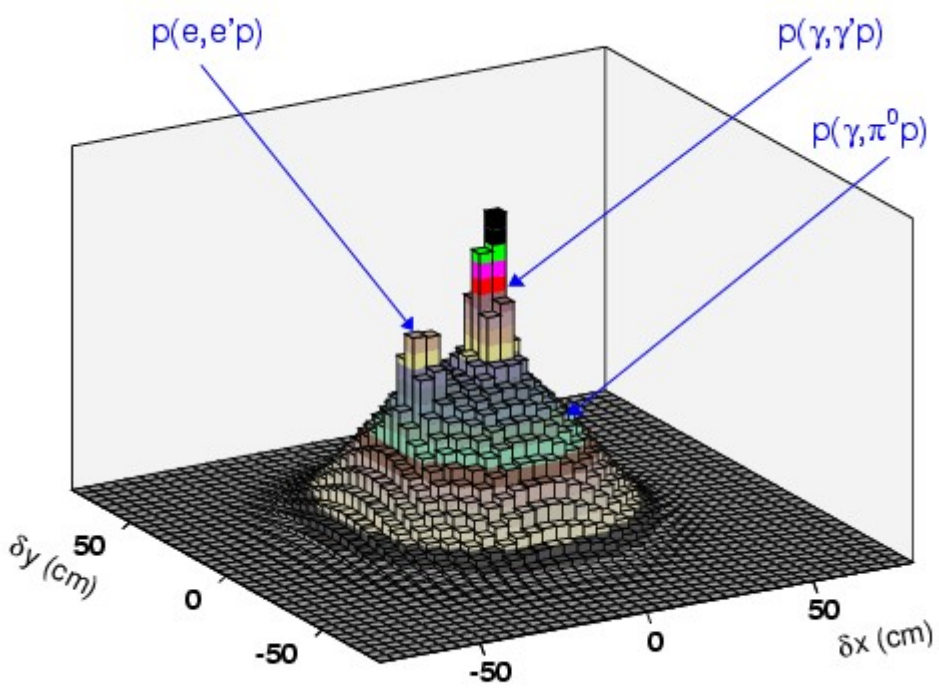




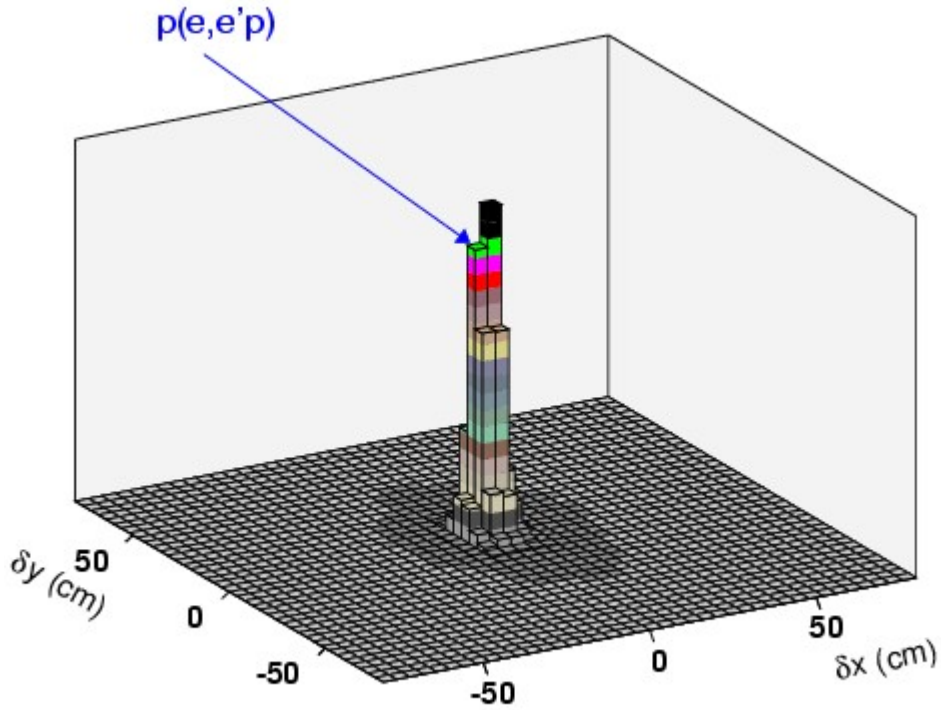
- Mixed electron/photon beam on target.
- Incident photon energy range defined by HMS acceptance.
- Employ magnet for electron deflection.

Analysis Technique: Event Selection

Off-endpoint kinematics

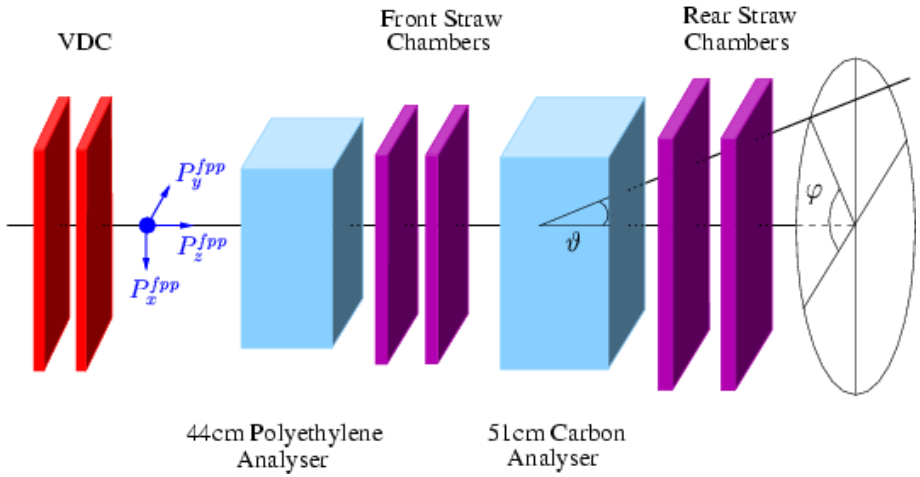


Endpoint kinematics

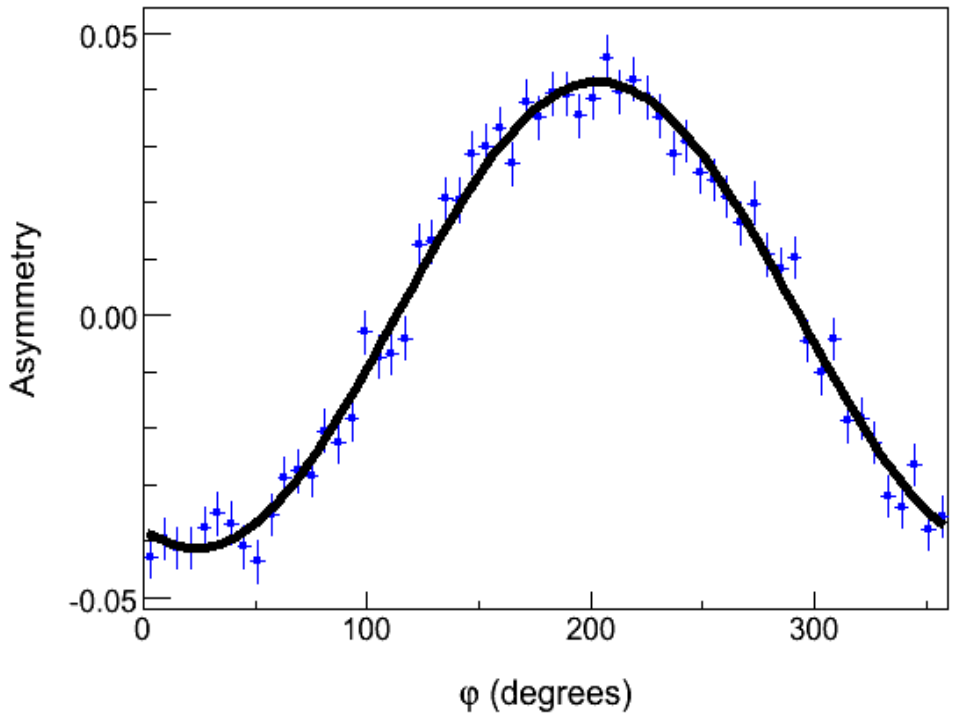


- Use two-body kinematic correlation to separate WACS and π^0 background.
- Depends critically upon combined HMS-BigCal angular resolution.

Analysis Technique: Polarisation Observables

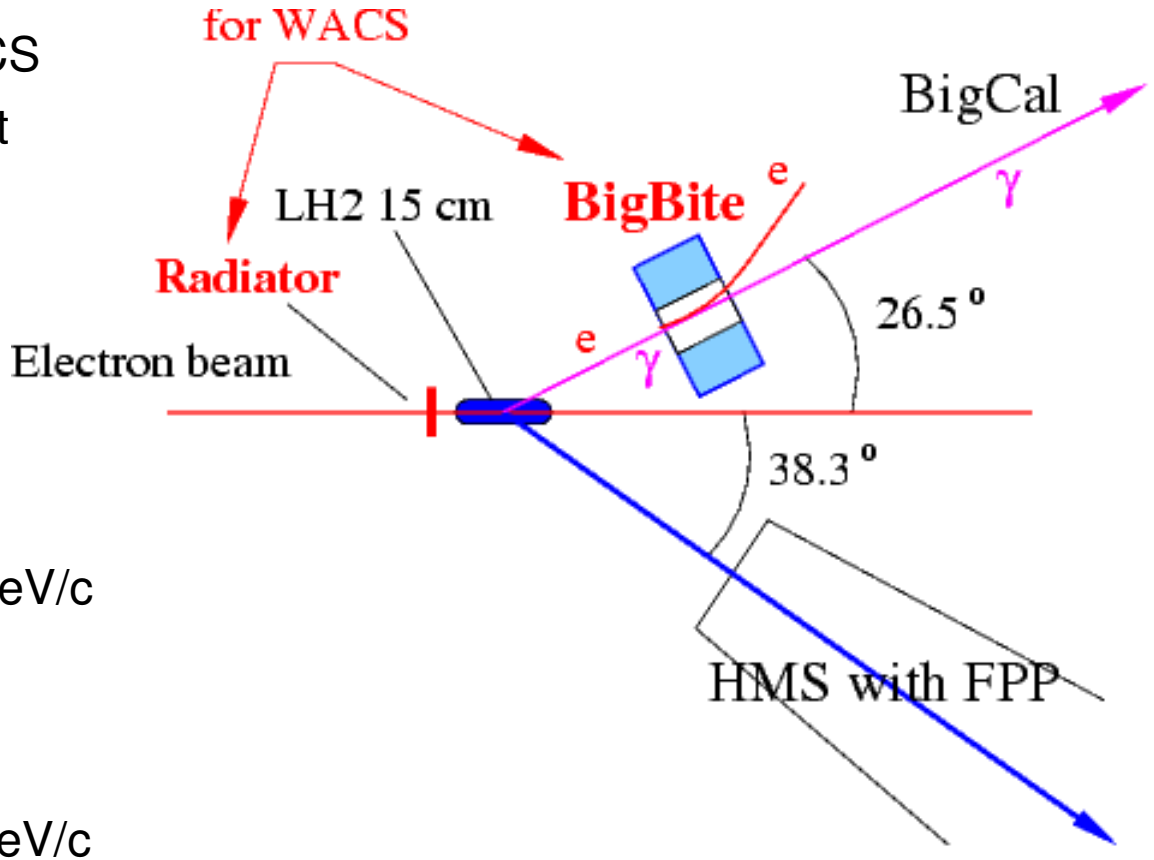


- Double analyser FPP used to extract beam-helicity asymmetries at HMS focal plane.
- Understanding HMS spin precession allows determination of polarisation observables at target.



Hall C Layout and Kinematics

- Only differences between WACS and GEp III are BigBite magnet and bremsstrahlung radiator.
- E_{beam} = 4.59 GeV
- Off-endpoint kinematics:
  $\langle E_\gamma \rangle$ = 4.1 GeV
  HMS θ/p = 38.3 deg / 2.02 GeV/c
  BigCal θ/D = 26.5 deg / 18.4 m
- Endpoint kinematics:
  HMS θ/p = 35.8 deg / 2.31 GeV/c
  BigCal θ/D = 26.5 deg / 18.4 m



Installation Plan

Friday 25/01/08 (Day)

- Move BigBite Magnet into place.
- Connect BigBite water supply and energise coils.
- Change S0 trigger scintillator in HMS detector stack.
- Make corresponding changes to trigger and coincidence timing.
- Move HKS magnet in order to free up some space.
- Move BigCal into position.
- Complete safety checklist.

Run Plan

Friday 25/01/08 (Swing) – Friday 01/02/08 (Owl)

- Check beam position and energy.
- Take commissioning data at endpoint kinematics
  - Optics data (sieve slit);
  - HMS alignment with C foils target;
  - check BigBite magnet deflection
- Take Moller measurement (Sat morning).
- Move to off-endpoint kinematics
  - Check counting rates, deadtime and calorimeter threshold
  - Begin production running

Online Analysis Plan

- Create /home/cdaq/WACS07 directory.
- Copy Analyzer and all necessary tools from GEp..
- Only minor changes necessary to the code.
- Monitoring of detector systems will be the same as GEp.
- Physics analysis of all data will be performed while experiment is running on the batch farm.
- Thanks to GEp students (Andrew, Mehdi and Wei) for agreeing to take analysis swing and owl shifts.

Contact People

- Spokespeople:

  Bogdan Wojtsekhowski (bogdan@jlab.org)

  Ron Gilman (gilman@jlab.org)

  Alan Nathan (nathan@jlab.org)

- Run coordinator:

  Bogdan Wojtsekhowski (bogdan@jlab.org)

- Analysis coordinator:

  David Hamilton (dhamilto@jlab.org)

- Website and Wiki:

  http://hallcweb.jlab.org/experiments/rcs/

Summary

- WACS is a powerful probe of proton structure, which is similar to elastic ep and DVCS and can be described in terms of moments of GPDs.
- Will learn more about reaction mechanism and non-perturbative proton structure.
- Experimental and analysis techniques are well understood and tested.
- Plans are in place for installation, run and online analysis.
- Shifts are all filled.
- Turnaround for results is expected to be relatively quick.
- We will have a PhD student for this measurement.
- 80 % of planned 12 GeV WACS programme will be in Hall C.